Surface roughness in the South Pole-Aitken Basin

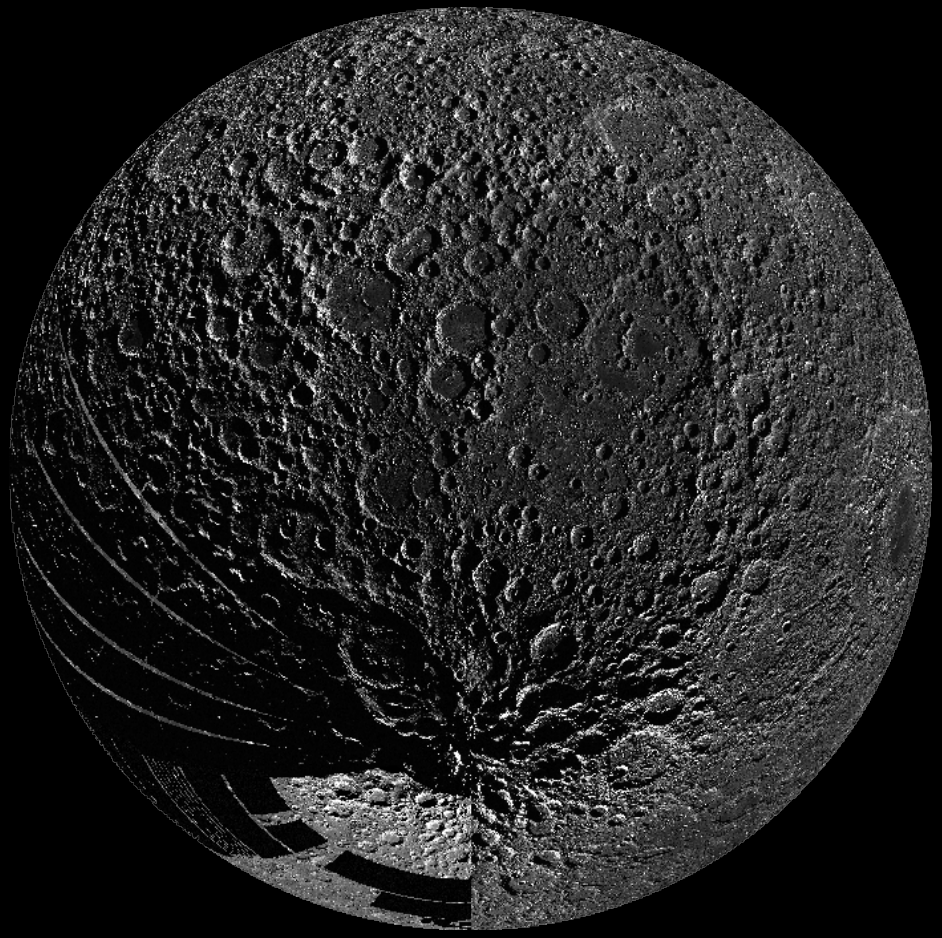
Noah Petro

July 22, 2015

NASA Exploration Science Forum

The Benefit of Face-to-Face Meetings

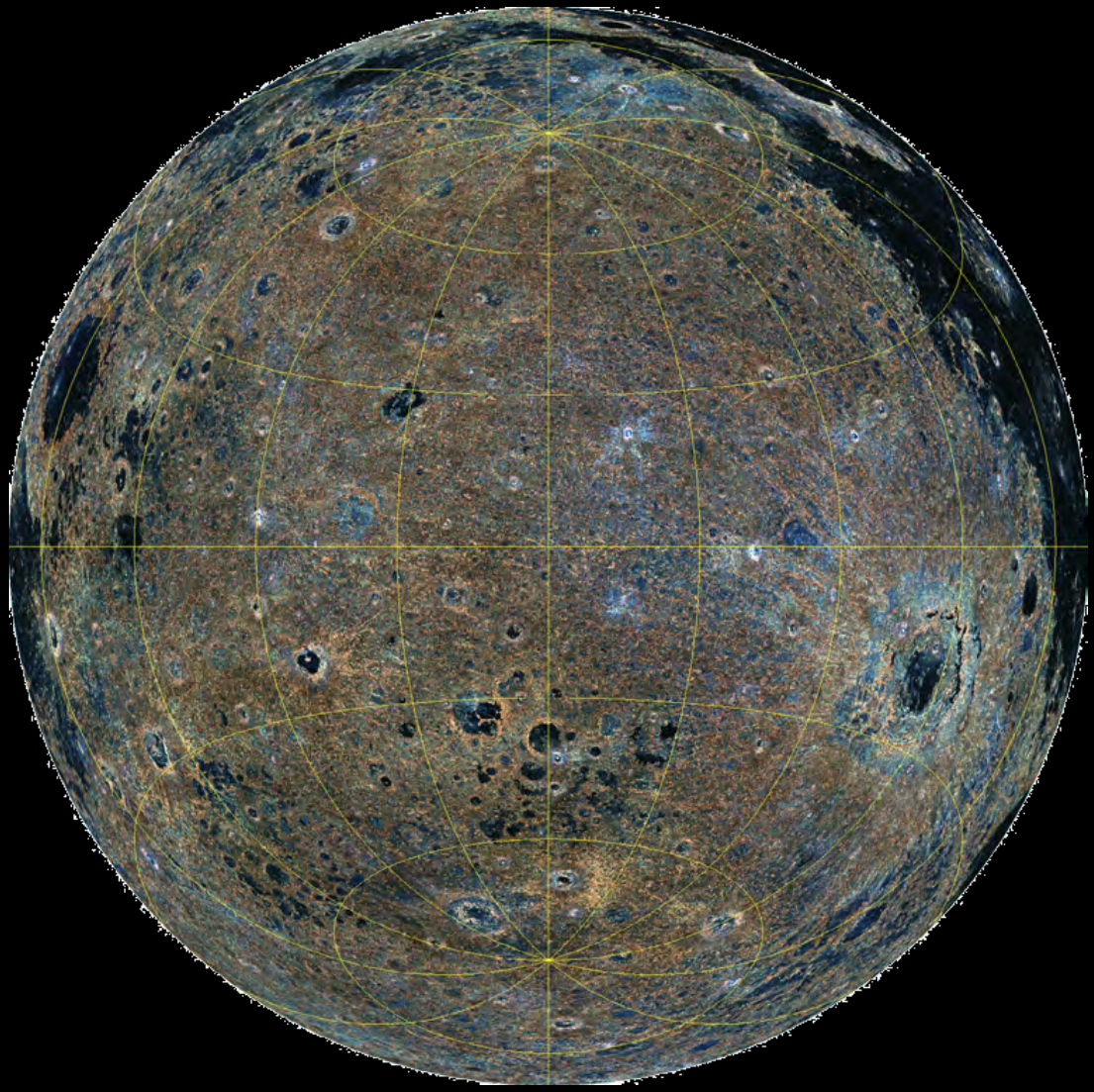
- Conversation at NESF 2014 with Bill Bottke, Becky Ghent, and Sara Mazrouei
  - Diviner data reveal an apparent lack of rocky, large craters in SPA
  - Yesterday this was discussed during M. Kreslavsky's talk
  - Where are the immature craters?
- What does the various views of roughness in SPA tell us about its history



LROC WAC
June 2012 Mosaic

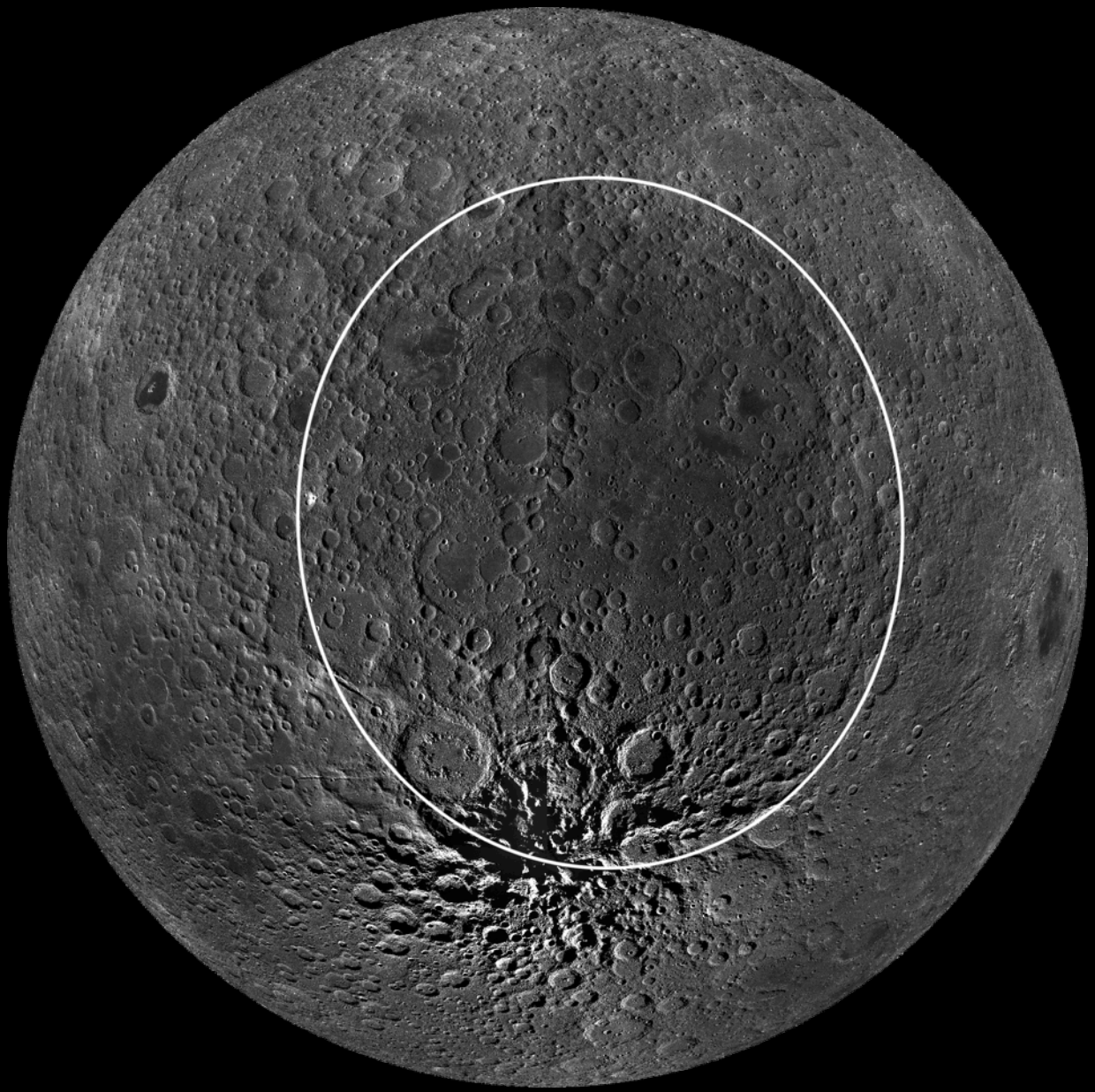
Multiple Approaches to Measure "Roughness"

- Mini-RF
  - Direct measure of surface/near surface blockiness
- LOLA
  - Roughness at varying baselines
- LROC-NAC
  - DTM derived topographic variation at the meter scale

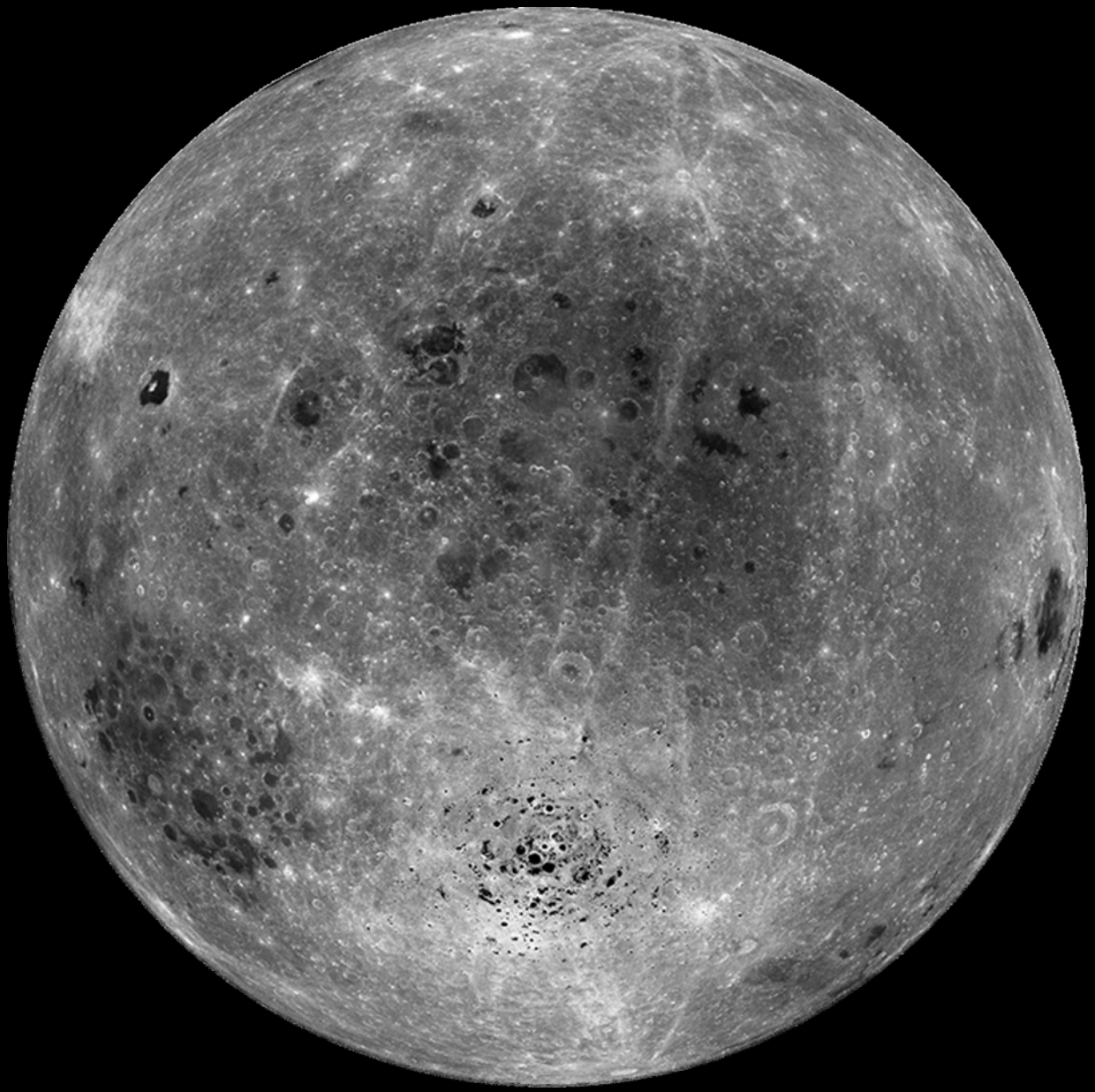


Kreslavsky et al., 2013, Icarus [LAMA projection]

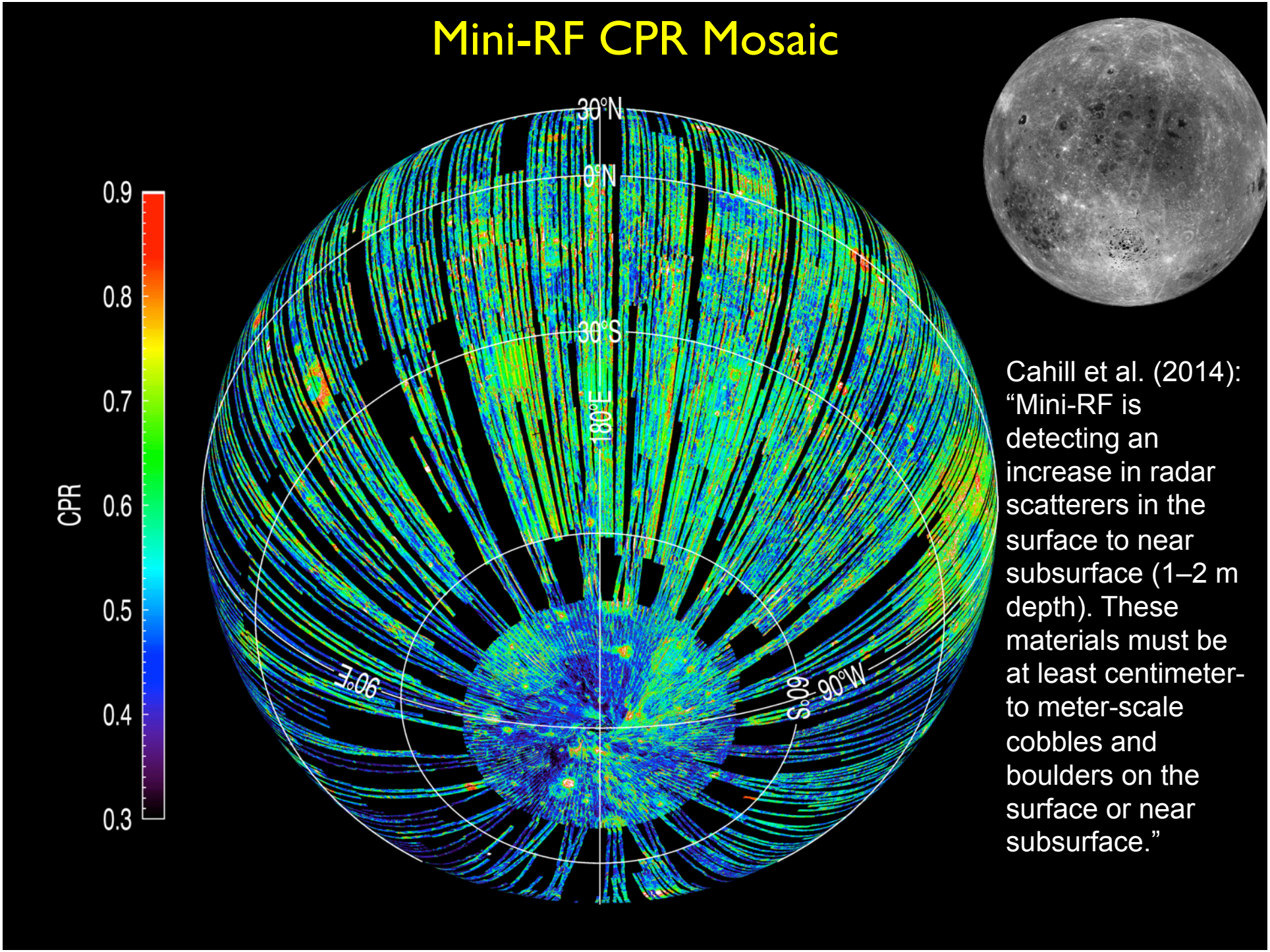
WAC Low-Sun Mosaic



WAC Mosaic – Empirically Normalized Reflectance

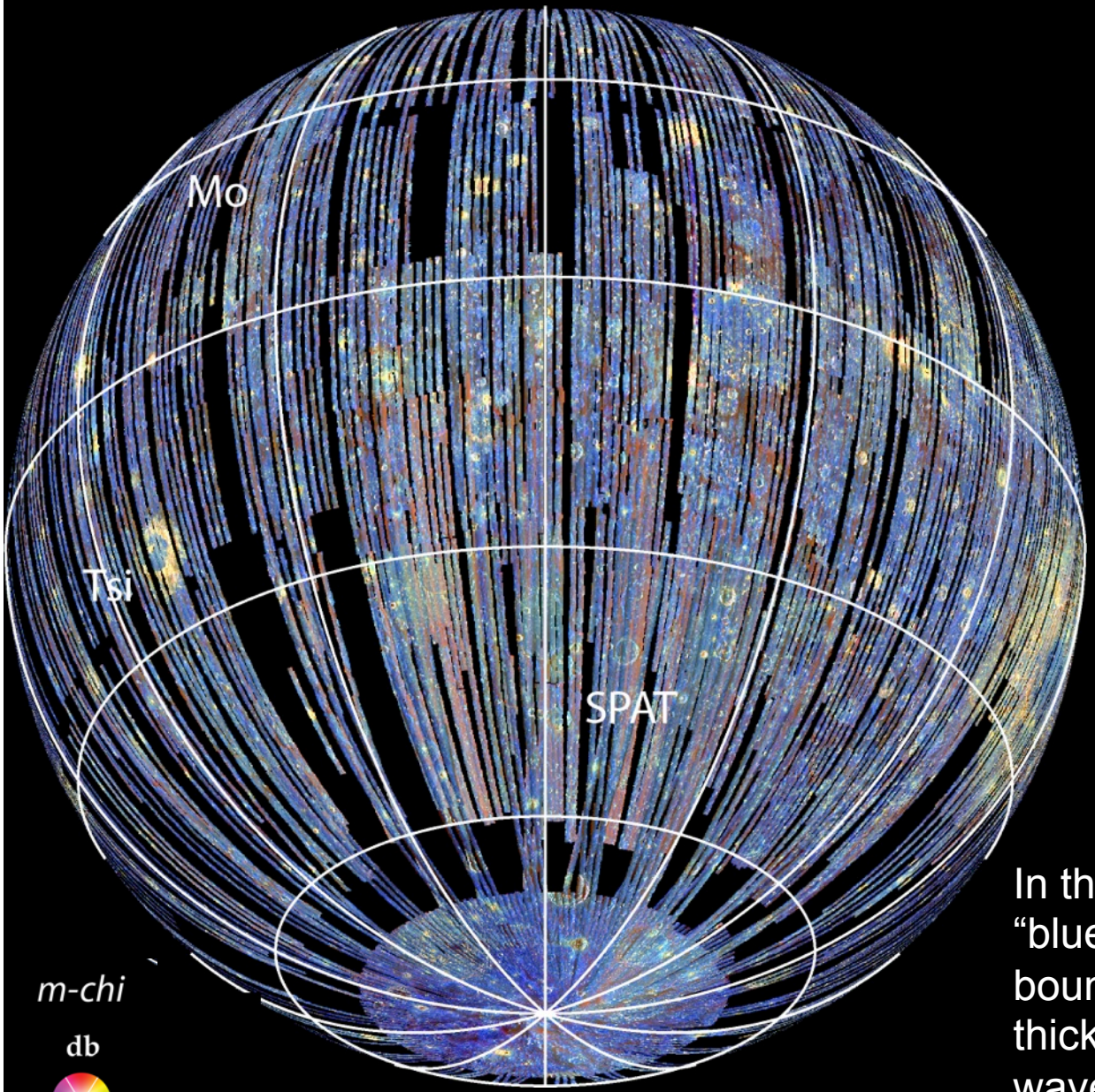


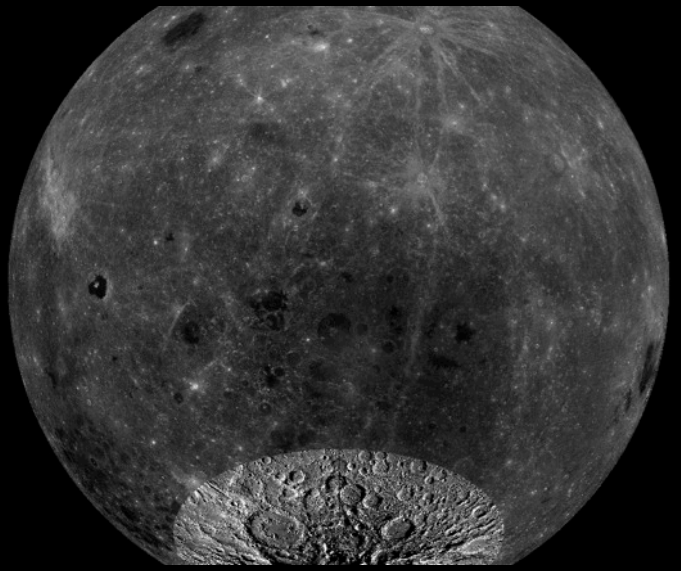
Mini-RF CPR Mosaic



Cahill et al. (2014): "Mini-RF is detecting an increase in radar scatterers in the surface to near subsurface (1–2 m depth). These materials must be at least centimeter- to meter-scale cobbles and boulders on the surface or near subsurface."

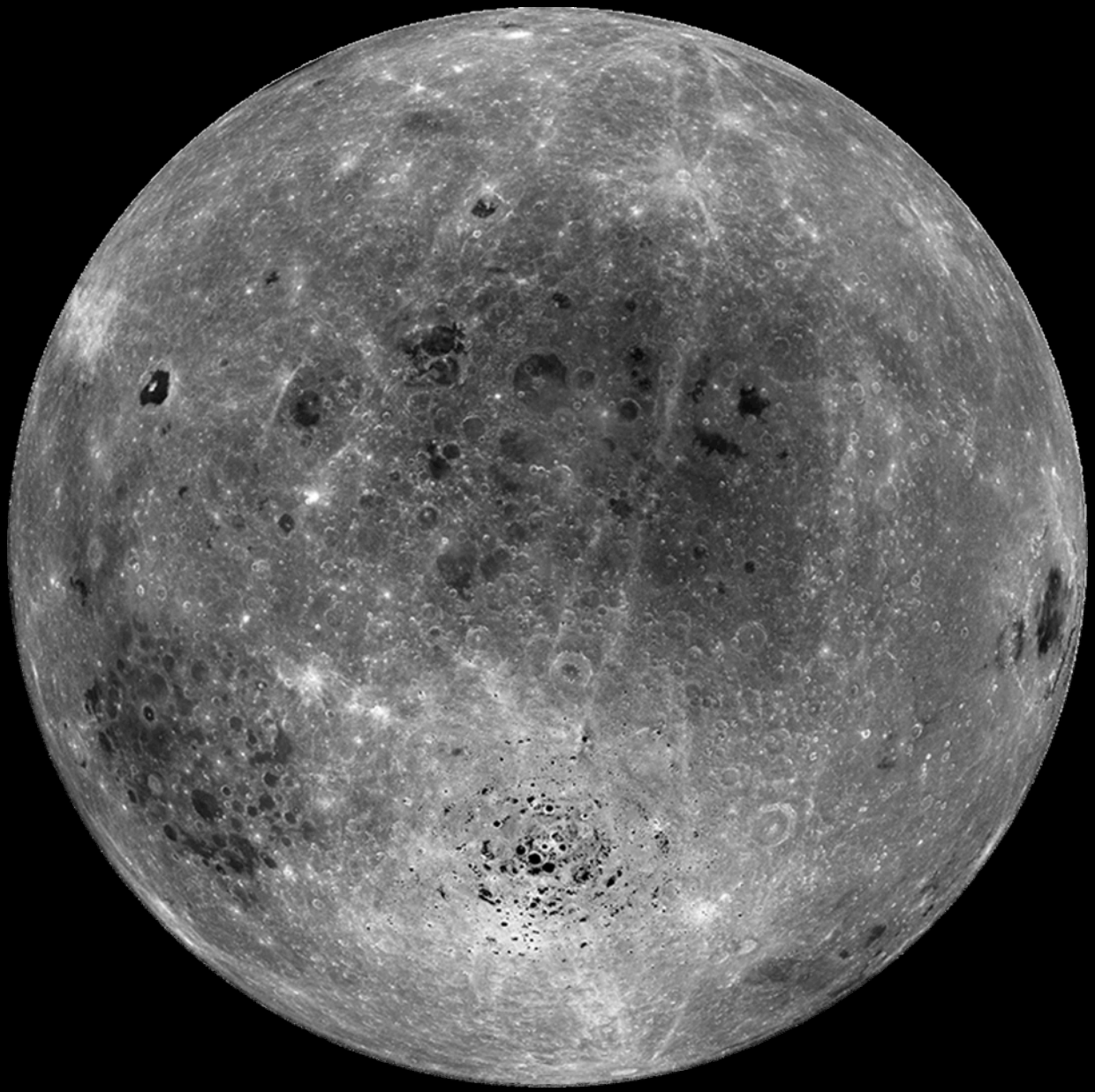
Mini-RF M-chi



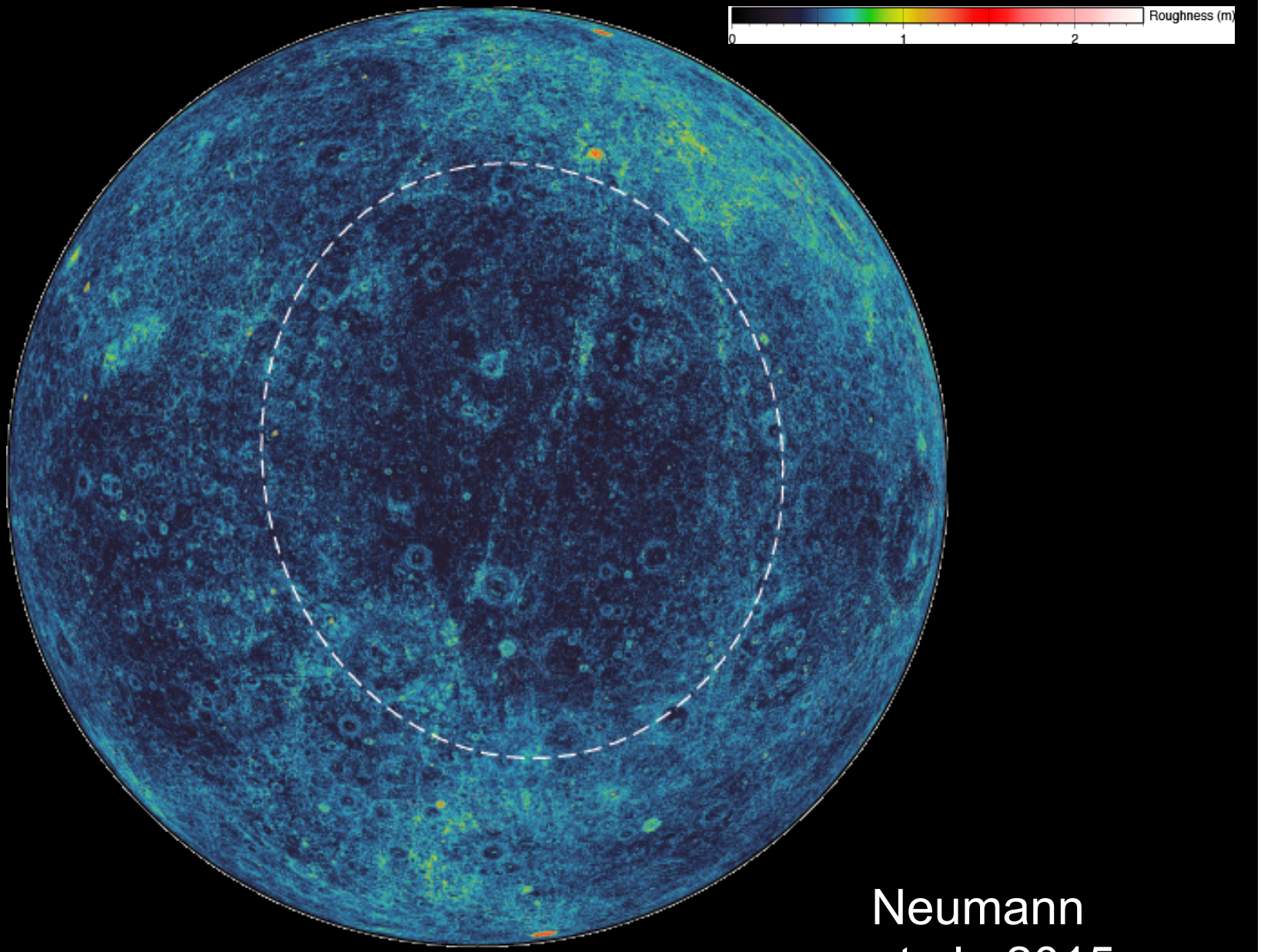


In the m-chi deconvolution, SPA is “blue”, indicatve of a single-bounce, suggestive of a 1-2 meter thick regolith with smaller than wavelength (12.6 cm) scatterers

WAC Mosaic – Empirically Normalized Reflectance



LOLA Roughness – 5 Spot Scale



Neumann
et al., 2015

LOLA Derived km-scale roughness – 1.8 km baseline

Kreslavsky et al.,
(2013, Icarus)

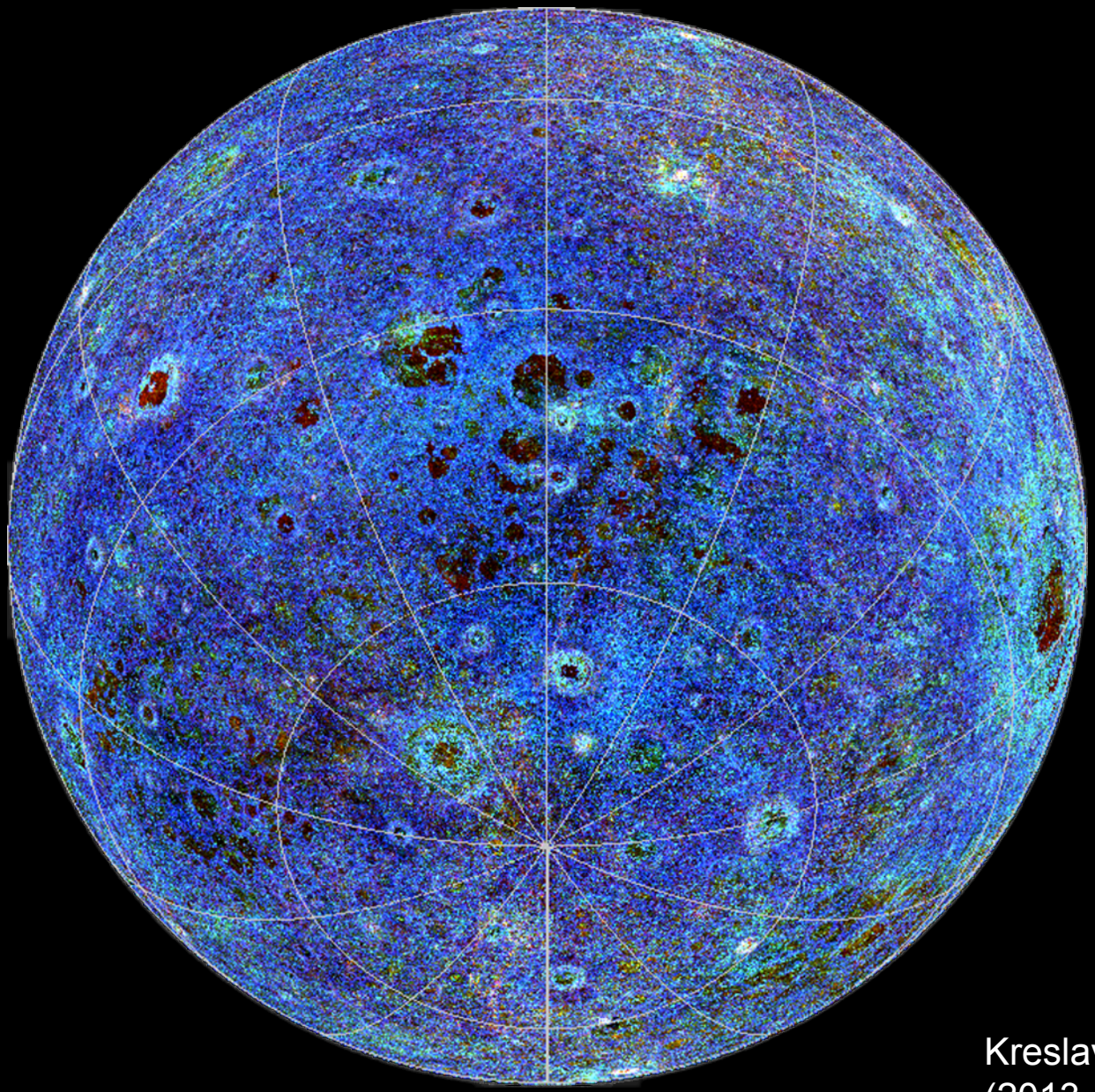
LOLA Derived km-scale roughness – 0.46 km baseline

Kreslavsky et al.,
(2013, Icarus)

LOLA Derived km-scale roughness – 115 m baseline

Kreslavsky et al.,
(2013, Icarus)

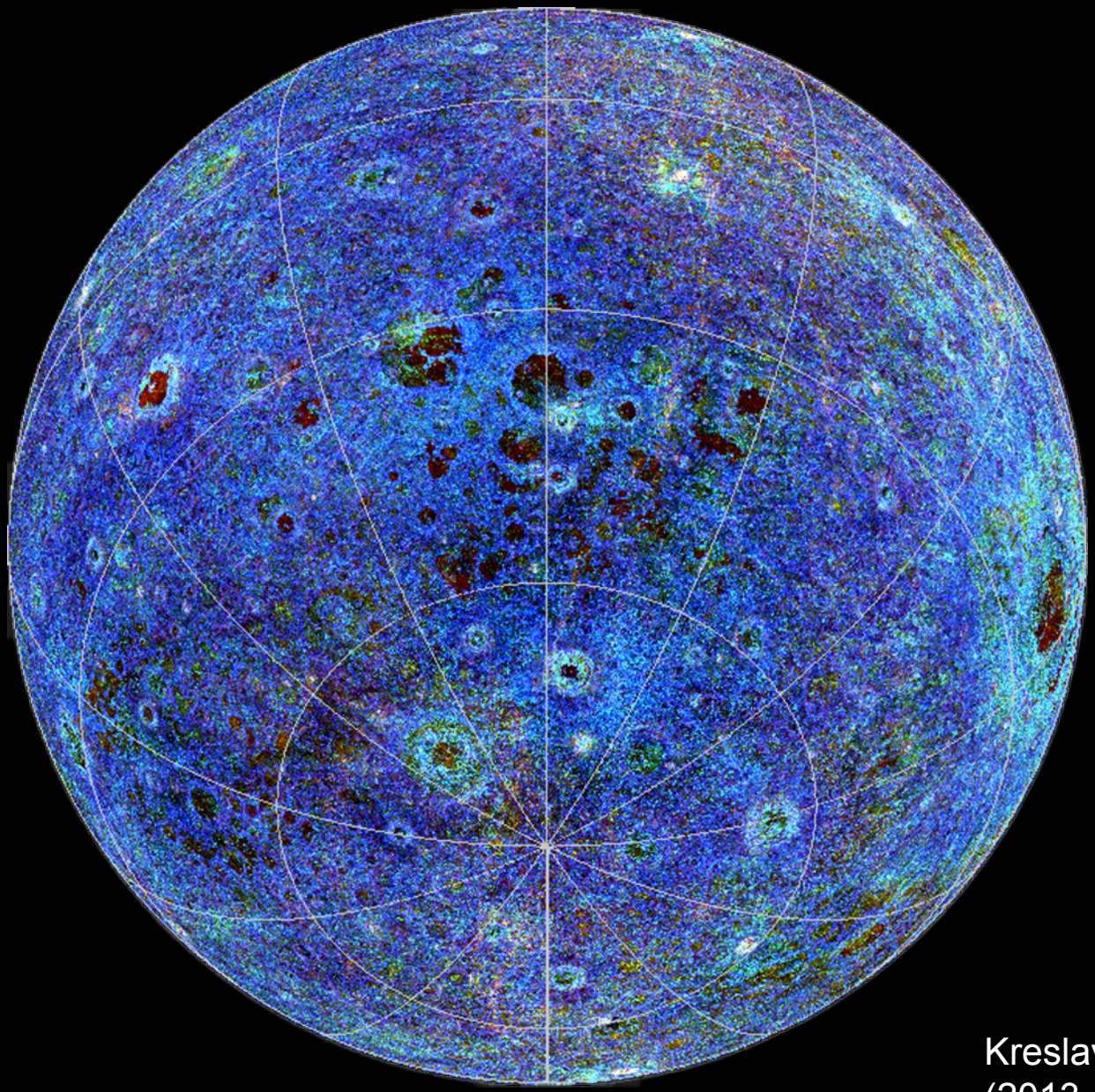
LOLA Derived km-scale roughness – RGB Composite



Kreslavsky et al.,
(2013, Icarus)

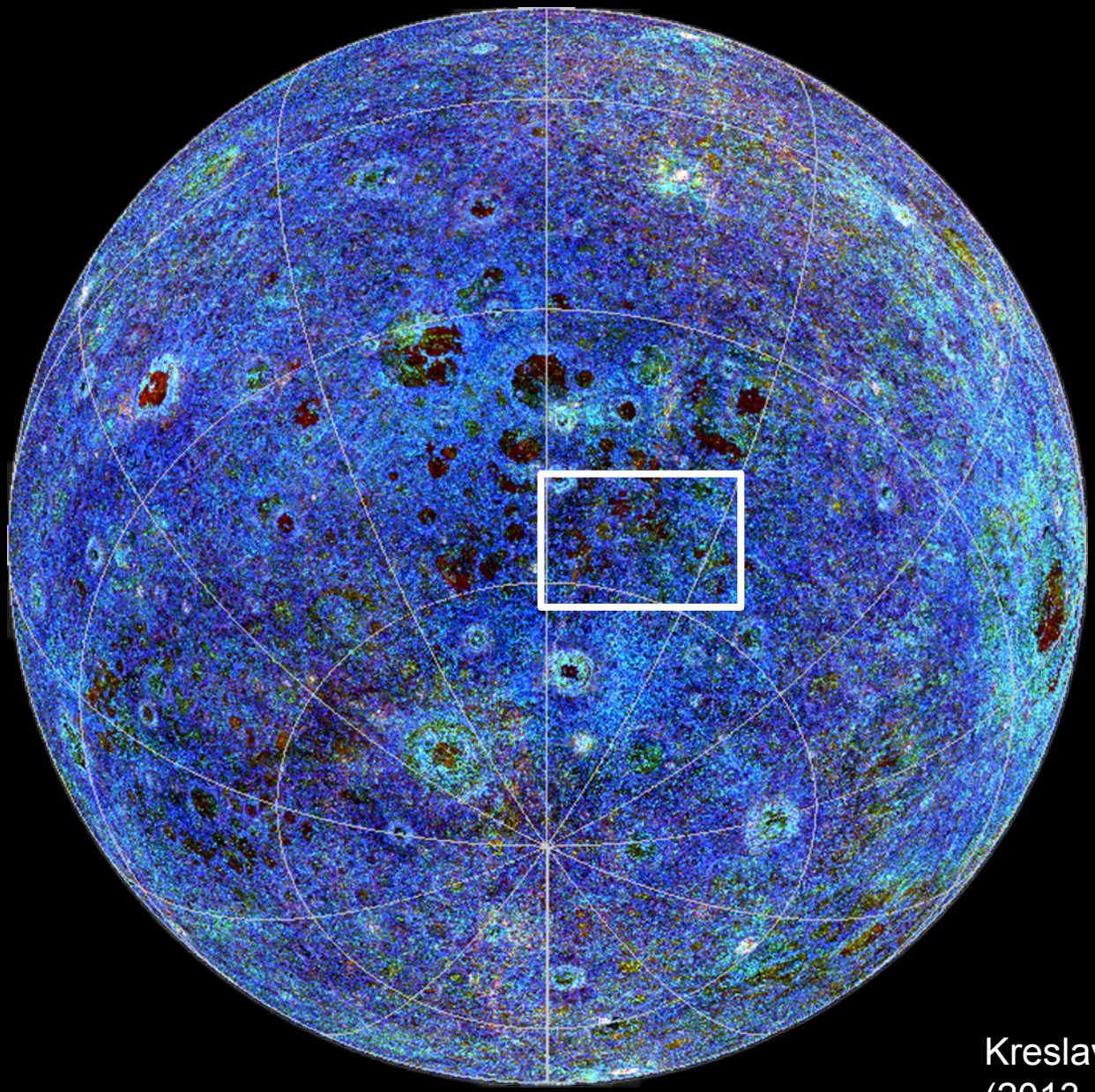

Kreslavsky et al.,
(2013, Icarus)

LOLA Derived km-scale roughness – RGB Composite



Kreslavsky et al.,
(2013, Icarus)

LOLA Derived km-scale roughness – RGB Composite



Kreslavsky et al.,
(2013, Icarus)

RIS^{4}E - Quantitative roughness patterns

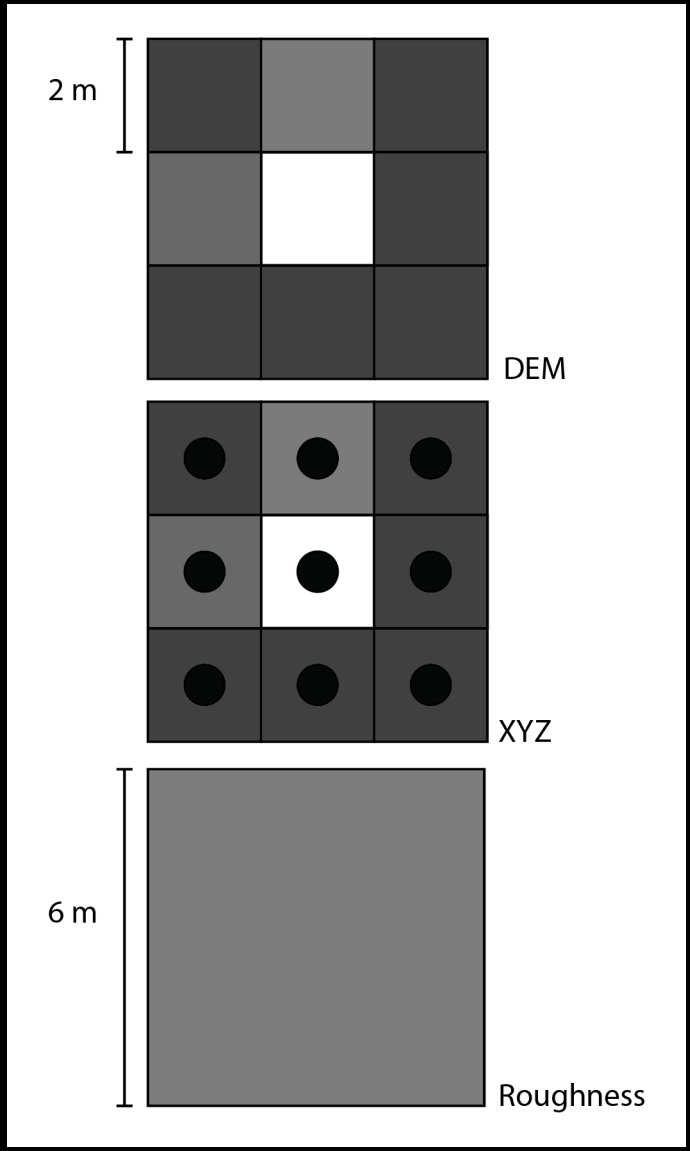
- Derive surface roughness (at any scale)
  - Space bourn, airborne, or in-situ
- Using a variety of data types
  - Light Detection and Ranging (LiDAR)
    - Method being used in support of RIS^{4}E
  - Radar
  - Photogrammetry
    - LRO NAC DTM's
      - Method used here
- Identify patterns in roughness
  - Co-occurrence statistics
    - *Whelley et al. IEEE TGRS, 2014*

Terrestrial LiDAR scanner

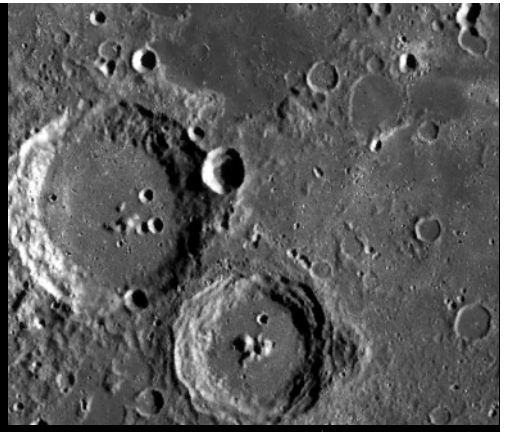
Kilauea Dec. 1974 flow

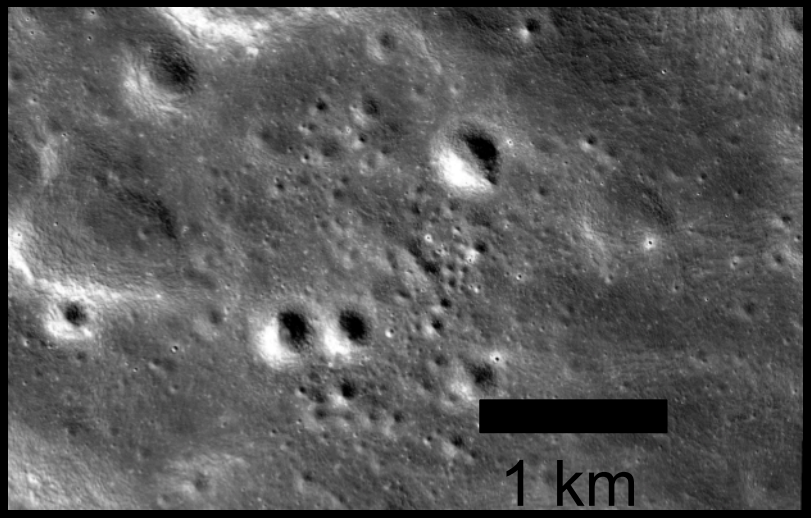
NAC DEM to roughness

- Start with NAC DEM
  - 2 m pixels
- Export as XYZ point cloud
  - One point per 2 m pixel
- Calculate 6 m roughness
  - Fit 6 m planes to point data
  - Standard deviation of residuals = roughness



Roughness in Bhabha East Plain





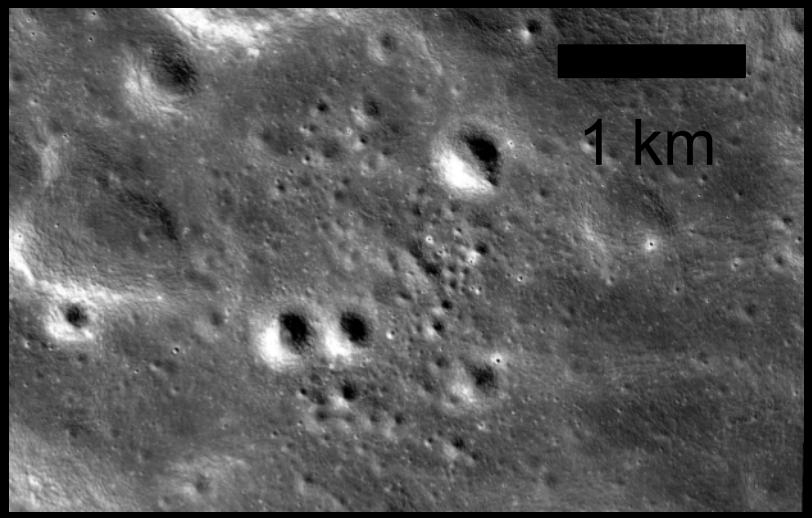
6 m roughness. Objects between 2 and 6 m contribute to roughness.

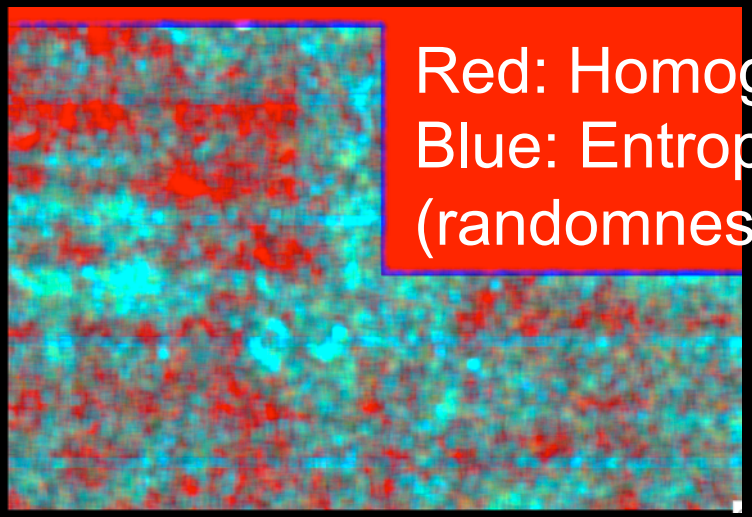
LRO NAC M112646261 (2 m resolution)

Roughness (6 m resolution)
- Lacks obvious features alone
- Further processing necessary

Roughness patterns

- Quantifies distribution of rough regions
  - Randomly or Homogenously

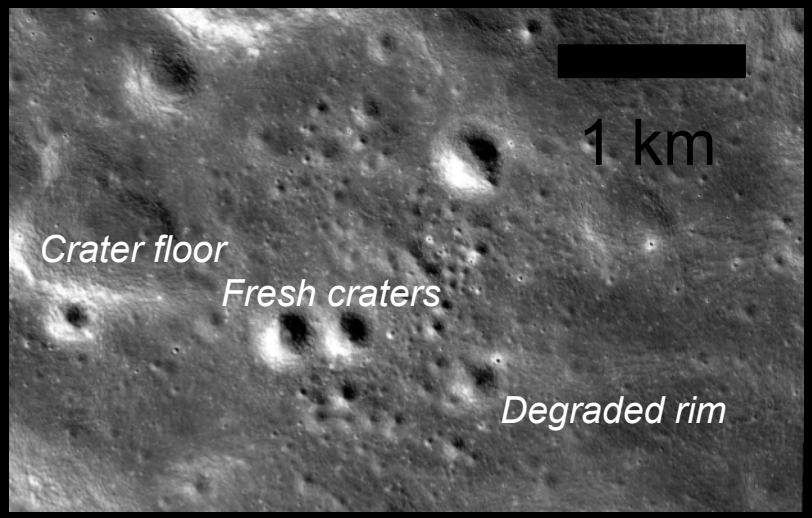


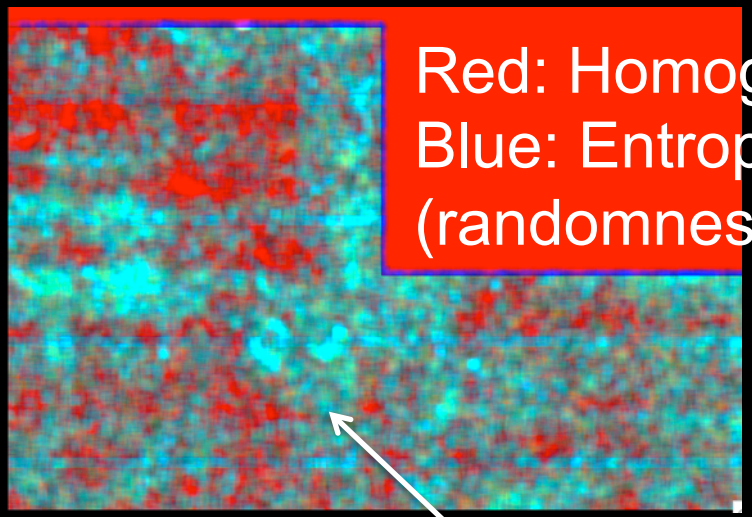


Clear relationships emerge

Roughness patterns – LROC NAC

- Quantifies distribution of rough regions
  - Randomly or Homogenously



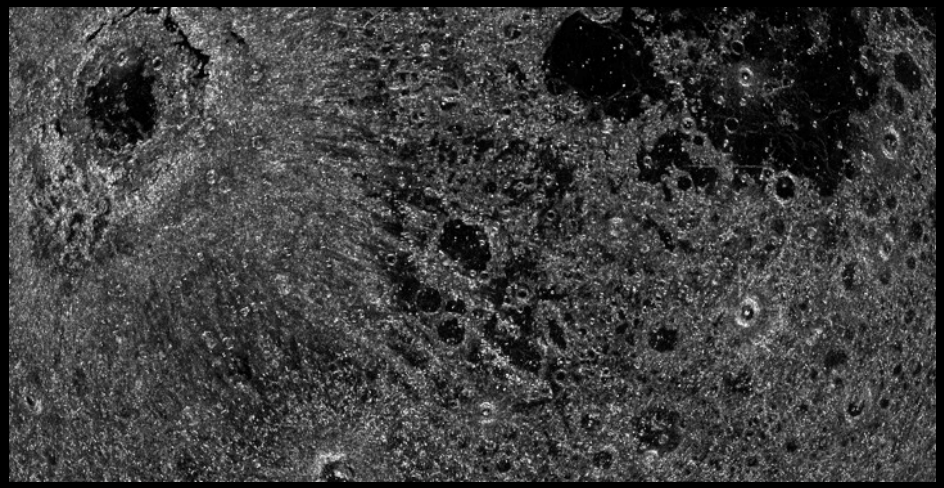


Smooth plain: High HOM
Crater rims: High ENT
Fresh crater: High ENT

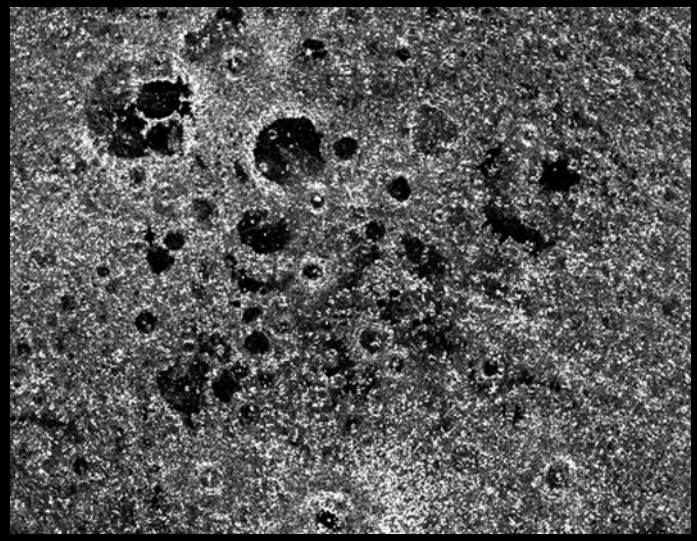
Buried crater rim? : Low ENT
Degraded crater rim: Low ENT
Crater floor: High HOM
-> Roughness patterns reveal surface textures on the Moon

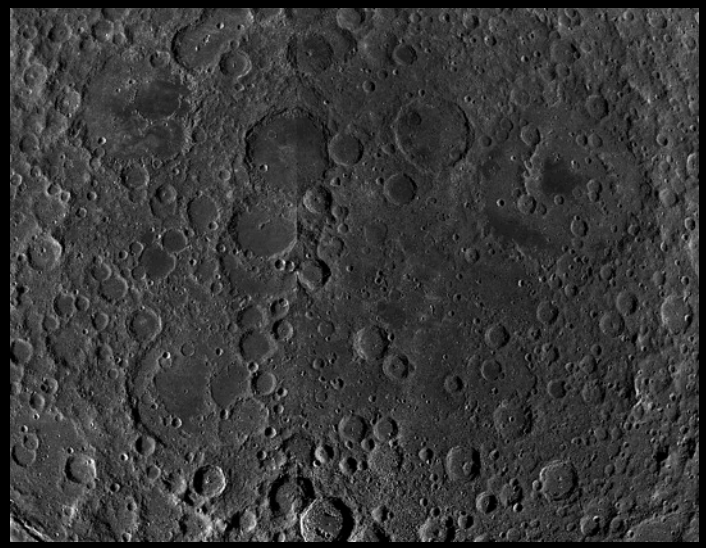
LOLA Roughness at 1.8 km scale

Schiller-Schickard



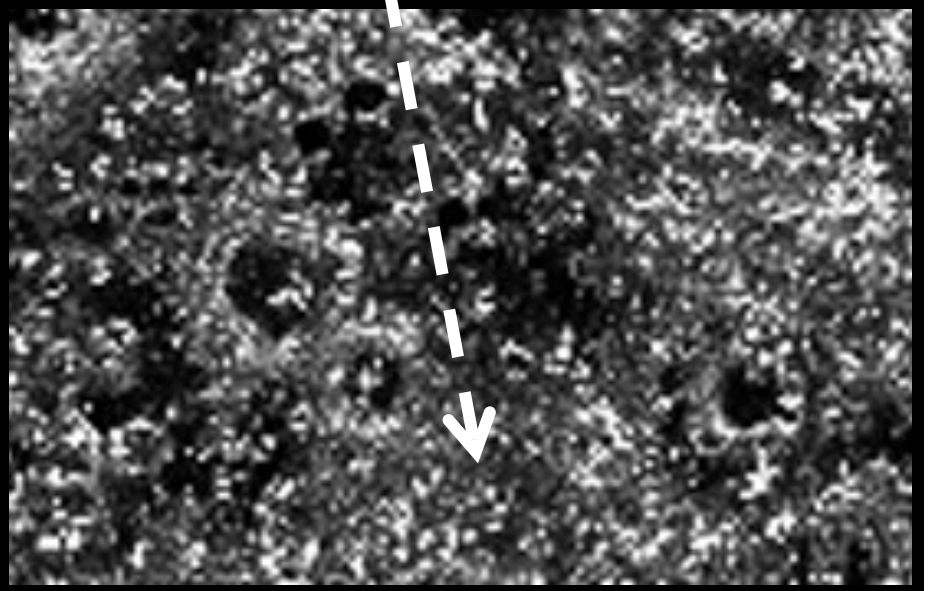
SPA





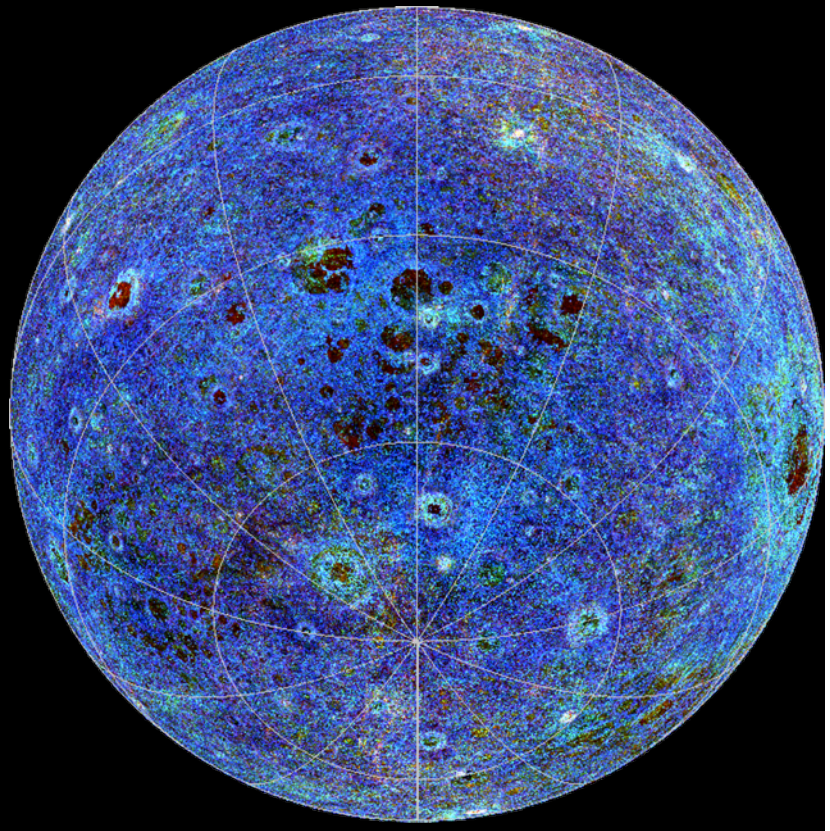
Roughness in SPA

- Variations in surface roughness reflect differences in formation and age (?)
  - Smooth mare basalts and ancient mare basalts/ plains units
  - Rougher surfaces, like that at Mafic Mound…
  - Mini-RF data illustrates a number of small, fresh craters, but no large fresh craters, consistent with Diviner RA



What's Happening In SPA?

- There are a number of craters with rough interiors but these are not rocky in the eyes of Diviner (cm-scale blocks)
- SPA is "smooth" at short baselines
- Not all of this smoothness is due to volcanism
- Effect of SPA formation, influence of Imbrium/ Orientale formation?
- Attend the SPA focus group meeting!



Backup